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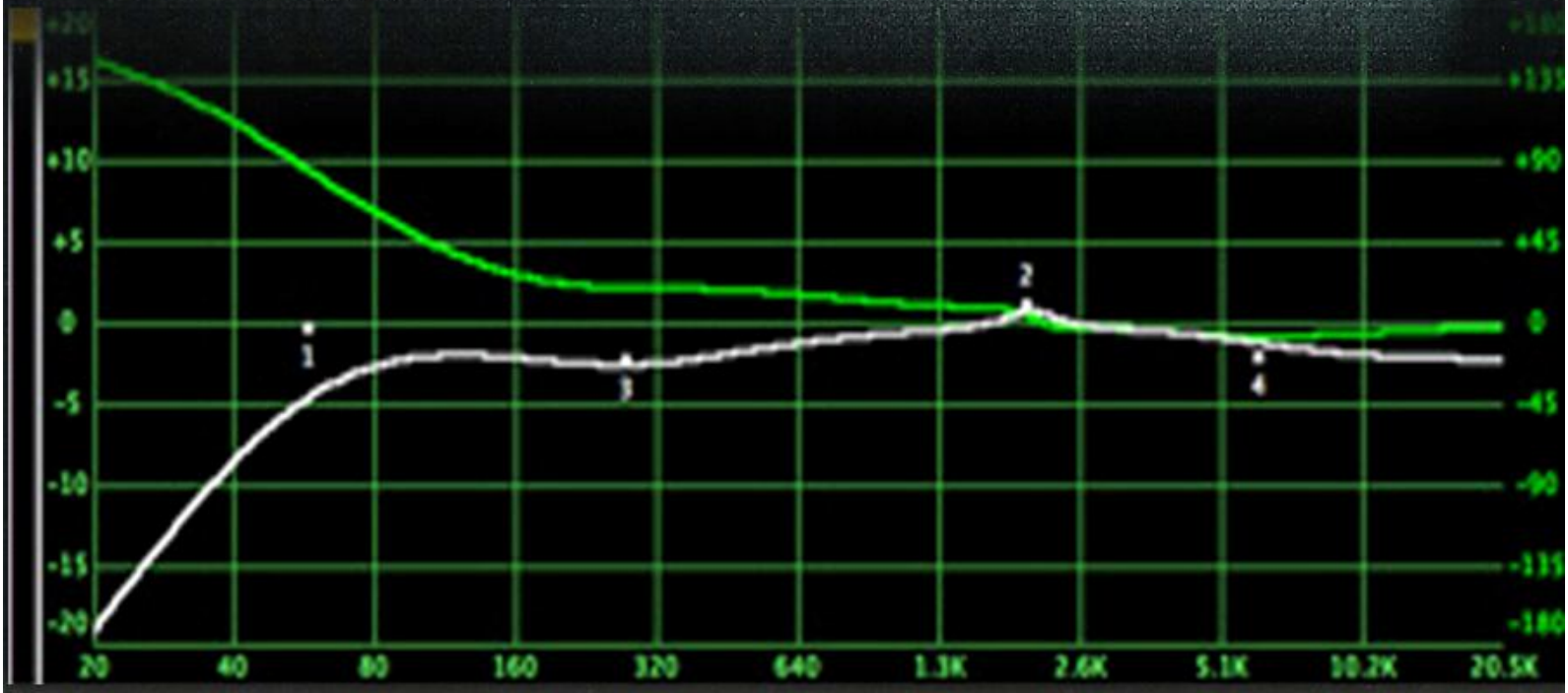

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Adaptive Emotional Personality Model based on Fuzzy Logic Interpretation of Five Factor Theory

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Abstract

In recent years, emotional personality has found an important application in the field of human machine interaction. Interesting examples of this domain are computer games, interface agents, human-robot interaction, etc. However, few systems in this area include a model of personality, although it plays an important role in differentiating and determining the way they experience emotions and the way they behave. Personality simulation has always been a complex issue due to the complexity of the human personality itself, and the difficulty to model human psychology on electronic basis. Current efforts for emotion simulation are rather based on predefined set or inputs and its responses or on classical models which are simple approximate and have proven flaws. In this paper an emotional simulation system was presented. It utilizes the latest psychological theories to design a complex dynamic system that reacts to any environment, without being pre-programmed on sets of input. The design was relying on fuzzy logic to simulate human emotional reaction, thus increasing the accuracy by further emulating human brain and removing the pre-defined set of input and its matched outputs.

Keywords: Personality knowledge, fuzzy logic, fuzzy logic, Five Factor Theory

1. INTRODUCTION

The term personality refers to the sets of predictable behaviors by which people are recognized and identified. These sets of behaviors go by the name of personality traits or factors. A contemporary view of traits considers in five dimensions, i.e., five-factor model of personality or the big five personality traits: However, Robot and human simulation has been an active research area in the recent years especially in the field of motion simulation and animation. Only recently, personality started to be a component in the artificial humanoids [1]. According to Doyle [2] emotions in robots has find a place in education and entertainment industry and emotions are becoming a part of several computer application ranging from computer games to artificial human interaction software's. Several approaches has been studied in this

field, and research is always expanding as there are no standards yet and every approach follows its own interpretation of human personality [1][3][4].

Current emotional system are either based on classical models of psychology such as Pavlov's model [5], which is according to Seligman [6][7]-too simplistic and has multiple flaws. EMMU on the other hand used the OCC model [8] which has been accepted by many researchers, however it has been pointed later by Bartneck [9] that this model is lacking historical information of the character, and needs improvements to be used as the sole concept of a personality model. Sumedha[1], depends on a model non related to the personality to generate the emotional reaction, it then applied a Bayesian set of predefined reaction to affect the personality. This system has a significant weakness which lies in the reaction generation, because it implies that reaction is generated with total independent from personality and environment. This contradicts the simplest foundation of personality analysis [10][11][12]. For personality factors we will be utilizing the Five Factor Model theory or FFM, which is becoming widely accepted by emotion simulation researchers [1][3][13][14][15].

The FFM theory is wider than the Pavlov model [6][10], in this work FFM will implemented using fuzzy logic which is a recommended approach for this theory by previous research [15][16]. Our approach is to take the human brain as the guide and use available psychology theories to simulate it. this mean that in the design stage our main concern is to comprehensively analyze the current psychological theories that describes human behavior and emotions, simulate it using simulation software such as MATLAB, and after implementing this architecture we will be comparing the result with the actual human test result data. In the proposed scheme, the system will follow a layered approach similar to the one imposed by Sumedha [1], and as mentioned above, that the system lacked the actual generation of emotional responses, it relied on another component e.g. a chat bot or text generator independent from their system, which generate reaction only by matching inputs with predefined set of outputs, and the system will convert these abstract reaction into multi emotional factors. Our contribution to this problem is to design a layered system based on fuzzy control that links reaction generation altogether with environment and personality. André *et. al.*[17] presented a comprehensive framework for personality modeling in computer generated environment based on FFM [18][19]. El-Nasr [17][20] used fuzzy logic to model the FFM. Vel'asquez [21] introduced the maulti layered models for personality-emotion relationships model to increase flexibility. Sumedha [1] have also used the FFM but he purposed emotion-mood-personality model and used Bayesian belief network for this implementation, and treated each personality factor from the FFM separately and did not cater for their correlation. Physiologist proposed that the combination of the five factors can produce distinct personalities and personality traits [1][18] which has a direct influence on emotional intelligence. We will start from this and use dual layer instead, proposed in [17] to generate an array of all usable personality traits that can influences emotions described in the OCC model [8] and design a fuzzy system that will interpolate the probabilities associated with the layer above i.e. mood. This layer considers Personality traits rather than personality factors, because the personality traits can be easily related [10] to the emotional response, rather than the raw 5 factors.

The rest of this paper is organized as follows; section 2 presents the background about the psychological concept. Section 3 presents our proposed scheme.

2. BACKGROUND INFORMATION

In this section, an explanation of the psychological concept will be presented. The FFM theory, human emotional system and the dual emotion-personality layer system will be highlighted. The statistical models and artificial intelligence approaches associated with FFM is introduced in order to derive our mathematical model for this research work.

2.1 The personality-emotion layer system: it is the dual layer that was proposed by previous research [17], emotional behavior seems to have multiple layers. The first layer is a static and invisible layer which is the personality. It is modeled using the FFM. The second layer is the emotional system which is a multidimensional system correlated with the personality. The probability of transition in the multidimensional space is dependent on the current state, outside stimulus and the personality factors.

2.2 Five Factor Model: The five-factor model is a personality model which describes personality and decompose it to five personality dimensions (OCEAN): Openness to Experience, Conscientiousness, Extraversion, Agreeableness, and Neuroticism.[22][10][11]. According to this theory, these five dimensions completely define a unique personality. They are mutually independent. Each of these major five factors depends on other minor more specific factors. From this concept, in order for us to describe a personality, we will have to provide values to the five factors. These traits are easier to decide on than the Big five ones. The unique combination of the FFM will define the uniqueness of a human personality. Personality definition thus contains a set of 30 small factors[23][10][11] (6 for each big one) and their values ranges from -1..1 to define the weight of that factor, so that -1,0 and 1 are extreme negative, neutral and positive respectively. This theory is one of the latest contribution in the field of personality anaylsis, and it has the best credit and accuracy compared with previous models [3][10][11][12][13].

2.3 Emotions: Emotion is the transient psychological, physiological and behavioral response to thoughts, events and social activity [24] and it has many types and categories so it is modeled as a set of independent variables, which forms a multidimensional space [8]. We will be using 7 dimensions to model the emotional state. The multi dimentional model for personality is proposed by the OCC model [8]. We will call this space $\boldsymbol{E^7}$ and we will define the emotional state as a vector in this state $\boldsymbol{v^7_i}$.

This the coordinate system of this 7D space will be modeled using 7 unit vectors, each perpendicular on each other

$$v_i^7 = [a\bar{i} \quad b\bar{j} \quad c\bar{k} \quad d\bar{l} \quad e\bar{m} \quad f\bar{n} \quad g\bar{o}]$$

where I,j,k,l,m,n,o are unit vectors and a,b,c,d,e,f,g are the normalized factor of each direction which ranges from [-1..1].

3. PROPOSED SCHEME STRUCTURE

3.1. Overview

The standalone system that we will be designing will act as an emotion processing unit (EPU). This EPU will take an input from the environment and process it to generate reactive emotions. The system is digital so it is discrete, and update interval will be controllable to enable the user to control how often the emotion reaction is generated. The system combines environment effect which comes as input stimulus or stimulation, with personality factors, and the current emotional state to generate the reactive emotional state.

The input of this system has 3 sources, first is the current emotional state which is the 7D vector v_c^7 from the internal components. Next is the emotional state of the current conversation the robot is engaged with v_e^7, we call this the environmental emotional state. The third is what we call the explicit interpretation pipeline P^5, which is a set of variables that has an explicit relation to certain emotion. For e.g. the number of humans in the room will have a positive effect on a social personality, given that the person is social, there will be high transitional probability to the happy state. Currently we will consider 5 of these explicit inputs which are Population of the, Current space, Temperature, Color variance, Audio noise, Input command rate. This way the current emotion will have an influence on generating the reaction emotion.

One thing to note is that the reaction emotion doesn't necessarily have to be the next emotional state, the next emotional state will converge to the reaction emotion, and the degree of convergence is decided by the current emotion. This approach is influenced form previous research [1]. This complex layered system will solve the problem of non related reaction imposed by the previous method [1] in which the reaction was independent by the current emotion and personality factors, and generated by an automated method which doesn't regard the current personality factors the fact contradicts psychological theories [10][11].

The inputs from environmental emotional state, the current emotional state and the explicit pipeline will be transformed into fuzzy states. The fuzzy rule set will determine the psychological relations between each input and the output. V_c and V_e will always reside in the same rule sets. P will be processed separately.

The architecture of the EPU will be based on fuzzy logic as shown in Figure 1. The FFM will use fuzzy logic to generate 13 personality traits that will be used in fuzzy rules. These personality trait will be the bridge that links FFM with emotional response [23].

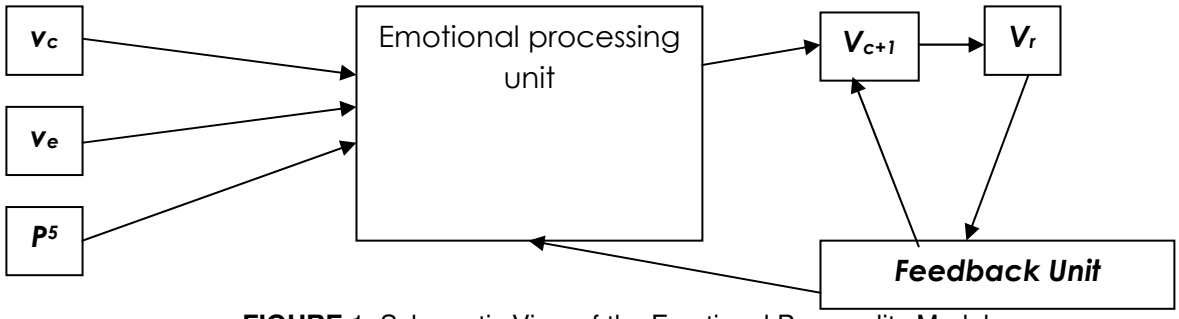

FIGURE.1: Schematic View of the Emotional Personality Model

3.2. Fuzzy Logic and Fuzzy Sets Related With Personality Traits

The term "*fuzzy logic*" emerged in the development of the theory of *fuzzy sets* by Lotfi Zadeh in 1965. He modified conventional set theory in which an individual could have a degree of membership which ranged over a continuum of values, rather than being either 0 or 1. The definition of the fuzzy logic formalism still relies on the conventional logic. *Fuzzy logic* is concerned with the reasoning about *fuzzy* events or concepts (like old, young, worry, angry, fear, and happy). Fuzzy sets and fuzzy logic possess far greater capabilities than their classical counterparts, their use considerably improves the bridge between mathematical models and the associate physical reality [27][28][29][30]. In order to model the flexible nature of human traits, we will be using fuzzy logic. The main motivation behind this concept is that we can never establish a fact that a person absolutely possesses a certain character. This relates to the foundation of human psychological theories being empirical and based on interpretation of statistical data [10][25]. Fuzzy states provide powerful tools to cover this uncertainty [26][27], and when it comes to psychology, it has been used to simulate personality factors in previous researches [15]. The person can

be neurotic to a certain extent which means he has a certain membership degree to being neurotic. Fuzzy sets and other approximation methods will be used in the current parts of our system

1. To calculate the degree of membership of personality character according to the initial values of the five factors.
2. To calculate the expected reaction to the current input state.
3. To calculate the probability of deviation from the current emotional state to the next emotional state.

In the first case, personality factors will be the multiple inputs for the rules in order to get the membership to each of the 13 personality traits. There will be no mixed interaction between variables from other domains. In the second case, fuzzy states will be based on rules that combines values extracted from emotional states, and from the explicit observational factors which are in a domain different from emotions. Using expressions such as

IF P_i AND V_c AND V_e AND Pt_i THEN V_r

We will get a fuzzy number for each of the seven dimensions of emotion.

The third section will use weighted average method to calculate the mixture between the raw and adjusted reaction.

3.3. Component description

In the following section we will describe the inner architecture of each of the components Input, Processing, and Feedback and Output.

Input: this component is responsible to gather different stimulations and transfer signals to the processing unit as set of factors. they way these stimulations are converted to signals is beyond the scope of this paper. What concerns us is that there is 5 subsets of signal and one emotional 7D vector, which are: Population of the current space, Temperature, Color variance, Audio noise, Input, command rate and current emotional states. the first five is s set of fuzzy numbers, each presented by a percentage of membership.

Processing unit: this unit is the core of the system, it is composed of 2 main parts, a fuzzy engine that generate personality traits value after deffuzifieng a fuzzy system based on the relation between the FFM and traits obtained from psychological test data [10][11][12], and the second fuzzy component will calculate the raw reaction or V_{c+1} using a complex fuzzy system that relates V_e,$V_{c,}$ Explicit pipeline P_i and the personality traits Pt_t.

Feedback: this component is responsible the degree of mixture between the raw reaction emotional state, and the current state. It will determine whether the emotional reaction will be exactly equal to the raw reaction, or to the current reaction, our a weighted mixture between them. In order to obtain the weights the system will compares our auto-generated responses with a set of empirical based data to determine the error margin in our simulation. The error margin will adjust the mixture level.

Output: The output component takes the 7 dimension data of emotion and fuzzifies it. it will determine the membership degree for each fuzzy value of the fuzzy number. This fuzzification can be used be a fuzzy control system to display the system as artificial facial expression or synthesized voice etc.

4.0 SIMULATION

The system has been simulated using MATLAB fuzzy toolkit, as shown in the figure (2) below, the system is composed of 32 inputs, which are 7 for each of Ve, Vc, 13 Personality traits, and 5 explicit pipeline inputs. The acquisition of the last set is beyond the scope of this research, as we are focus on the EPU itself not the devices that are pluggable to it such as sensors and microphones. It will be provided as part of the simulation input.

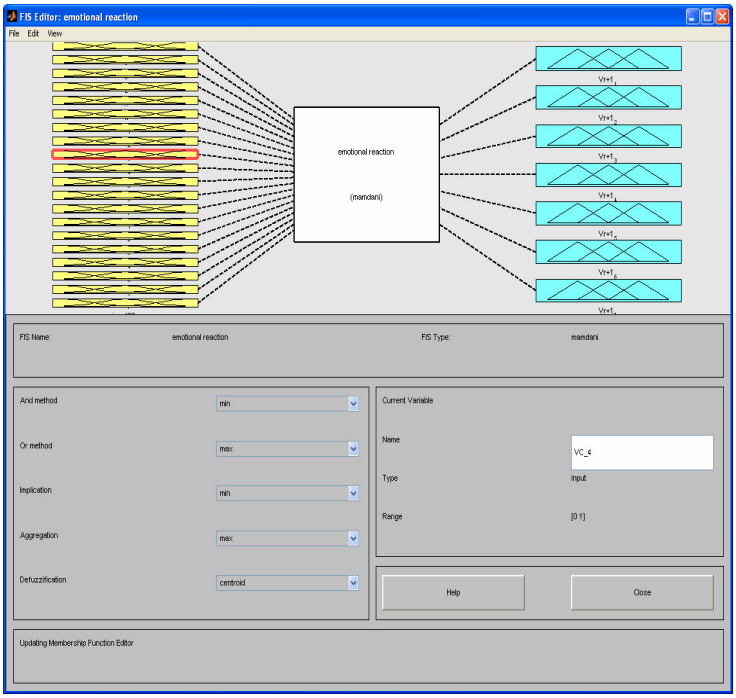

FIGURE.2: Snapshot of the Simulation using MATLAB fuzzy toolkit

Each fuzzy number has three fuzzy values which are hi medium and low respectively. Gaussian curves where chosen to plot the fuzzy values for emotional inputs, to increase the smoothness of the blending between different curves. Personality traits have normal triangular curves as they are queried form another personality fuzzy system (Figure 3).

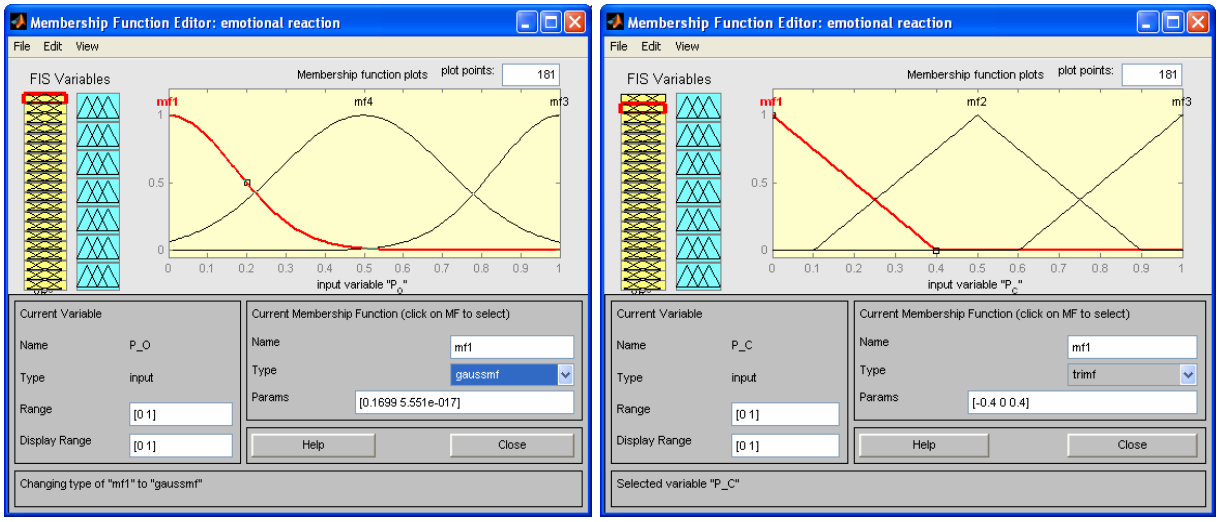

FIGURE. 3: Simulation of Emotional input and Personality Traits

Defuzzification will provide us with the results for the output. These results will be adjusted so that the feedback system minimizes the error margin. The formula is

Vr = (e)Vc+ (1-e)Vcr+1.

Where *e* is the weight constant which is initially 0.5. it is directly proportional with the error percentage, thus the less the error the more the values will equal to Vr+1.

Not the personality traits are obtained through fuzzy system of 5 inputs and 6 outputs which fed into the fuzzy system above.

And example of the operation of this system is as follows:

A personality with factors (O, C, N-, E+, A+) was talking and the emotions of the conversation was happy and his current emotion is neutral, and the temperature is warm, and room population is high

Fuzzy Rule associated:

IF O AND C AND N- AND E+ AND A+ THEN PT_4+

PT_4 is a social personality. This will be fed into the next stage

IF PT_4 AND Vc1+ AND P_1+ AND P_2+ THEN Vr+1_1+

The deffuzified value will equal to 0.378 of happiness.

This means that if a social personality (O, C, N-, E+, A+) conversed about a happy topic there is a maximum chance of 37.8% of his next emotional state becomes happy. Empirical data suggests the ratio of 41.1%.

Higher accuracy are achieved by balancing the system with more real test data.

With the sample error data the weight constant will be adjusted accordingly so that the nest case will be more pushed towered Vr (less percentage).

Table 1 shows the effect of the feedback system on having the same input fed different times. The Input gap is the number of other inputs that separates this same input case.

TABLE 1: The effect of the feedback system on having the same input fed different times

Input	Gap of inputs	Error %
1	-	4.52
2	5	2.64
3	6	1.13
4	4	0.92

5. CONCLUSION & FUTURE WORK

By this we have successfully simulated the system which implements the five factor model. We have presented an emotional simulation based on one of the latest and most popular theories of personality analysis, recommended by multiple researchers. We have solved the problem of the outdated theories of psychology, and we have presented a feedback system that will solve the problem of historical input effect. Also, our system is not dependant on pre programmed couples of input-outputs, it is fully independent and dynamic, and operates under any possible input.

In order to increase the accuracy of our system we propose including more empirical data to compare with. The more accurate the data the more accurate is the feedback system which means that error will be reduced over period of usage of this system.

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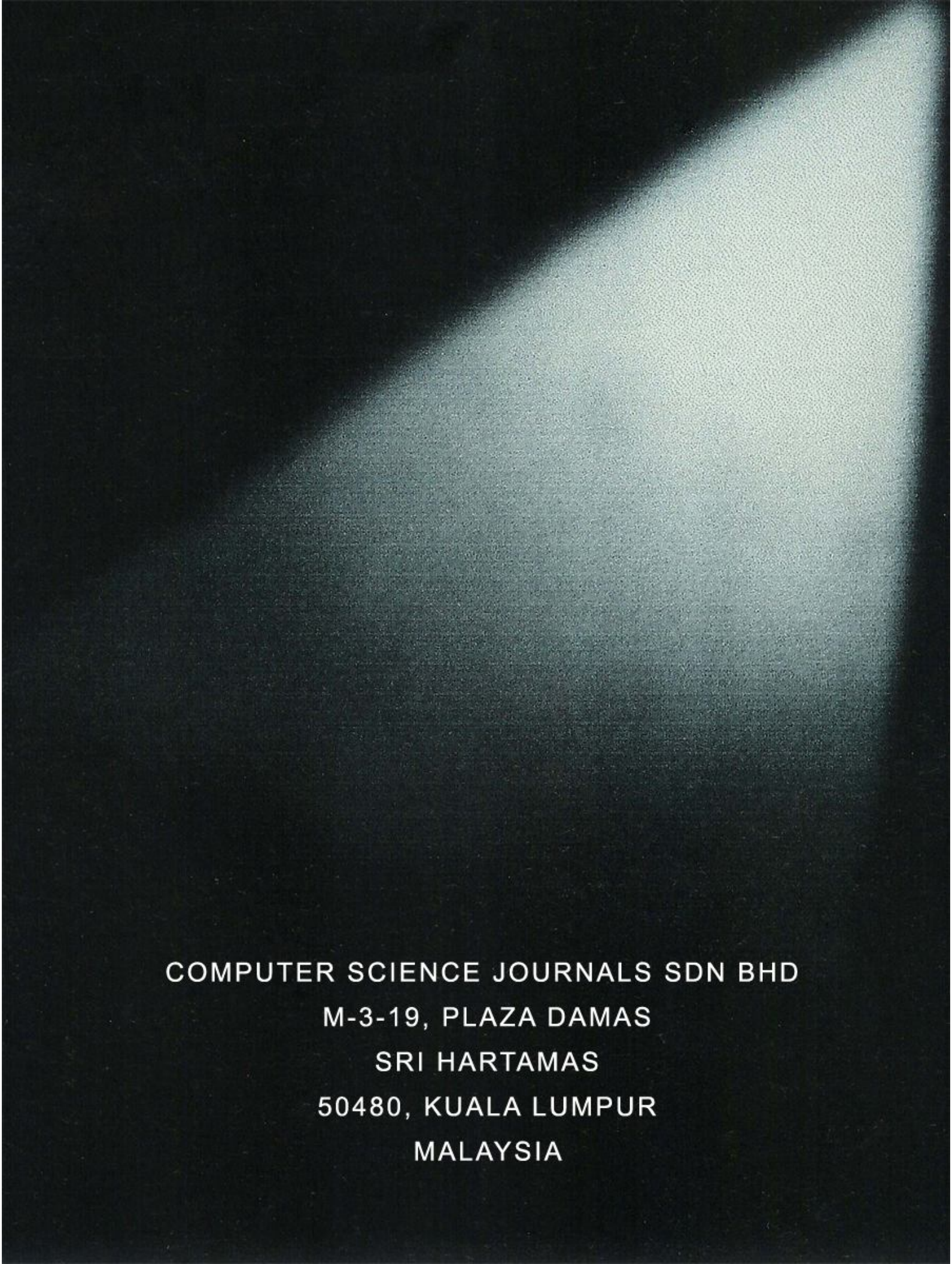

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